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ABSTRACT

A program is described that was developed, implemented, and evaluated at the P.K. Yonge Laboratory School at the University of Florida. It was designed to help middle school students to increase competencies in basic computation. The nine criteria guiding development were: 1) individualized instruction; 2) greater student responsibility for learning; 3) positive reinforcement for student successes; 4) computation skills basic to developing skills for living; 5) procedures to assist in focusing student and teacher on one skill at a time; 6) a records system; 7) instruction sequence from easy to difficult; 8) design for ready incorporation into existing programs; and 9) compatibility with minimum performance standards in Florida Department of Education basic skills. The program was designed to be individual and self-paced, with pupils primarily responsible for determining when they have acquired sufficient skill to demonstrate mastery. The program was tested with the sixth, seventh, and eighth-grade classes during 1978-79. In general, pupils obtained positive changes in grade equivalent scores of more than one year. It was felt the results were sufficiently positive to warrant examination of use of the system in public schools. (MP)

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THE P. K. YONGE BASIC MATHEMATICS COMPUTATION SKILLS SYSTEM: A PROGRAM OF INDIVIDUALIZED INSTRUCTION WITH AN EMPHASIS ON DISCRETE ELEMENTS OF COMPUTATION SKILLS

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by

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Winter, 1980

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PREFACE

When groups of students reach the middle grades, there are marked differences in their computation skills. If they are divided into homogeneous groups in order to provide instruction appropriate to each group's needs, there is likely to be little positive modeling within groups of the less proficient. Furthermore, being placed in a "low" group is likely to reinforce the student's negative perceptions concerning his capabilities.

The program described in this monograph provides instruction in the basic computation skills that is geared to each student's individual needs, without the disadvantages of homogeneous grouping. Progress is systematic. Each student moves at his own pace from the skills which are easily acquired to the more difficult. Check points provide continuous feedback so that the student usually does not leave a skill until he has command of that skill.

Preliminary data show that the program works. We hope it will prove useful to you either as described or as adapted to your situation.

J. B. Hodges, Director
P. K. Yonge Laboratory School
and Professor of Education

CHAPTER I

THE P. K. YONGE BASIC COMPUTATION SKILLS SYSTEM

One of the persistent problems in education is helping students acquire basic computation skills. Middle school educators have particular interest in this problem since a significant portion of the middle school mathematics program is devoted to acquiring computation skills. Current efforts to deal with this problem are evidenced by recent activities and publications of the National Council of Teachers of Mathematics and the Florida Educational Accountability Act of 1976. For the past two years, the Mathematics Department of P. K. Yonge has addressed the problem through research. The result has been the development, implementation, and evaluation of a system specifically designed to cause middle school students to increase competencies in basic computation.

Nine specific criteria served to guide development. They were: (1) individualized instruction, (2) greater student responsibility for learning, (3) positive reinforcement for student successes, (4) computation skills content that is basic to developing mathematics skills for real-world living, (5) procedures that will assist the student and teacher in focusing efforts on one skill at a time, (6) a system of records for students and teachers, (7) a sequence of instruction that proceeds from easy to more difficult, (8) a ready incorporation of the system into an existing middle school mathematics program, and (9) compatibility with the minimum performance standards in basic skills as developed by the Florida Department of Education.

The resulting system consists of a division of the basic computation skills into discrete components, a nontraditional sequence of student progress through these components, a self-paced individualized mode of instructional materials for student and teacher use, and suggested procedures for use of the system. The materials are student learning papers, student mastery quizzes and tests, student progress charts, teacher class record forms, and teacher solution keys to quizzes and tests. These elements of the system are described below.

Basic Skill Components

The body of skills identified as basic arithmetic computation skills have traditionally included addition, subtraction, multiplication, and division with whole numbers, fractions, and decimals. In addition, the P. K. Yonge Computation Program includes number concept and percent skills

in order to make the program more compatible with the requirements of the Florida Testing Program. The system separates the body of skills into components that are specific and distinct in terms of skill content or degree of difficulty. This separation allows the student and teacher to focus their attention at any particular time on a small portion of the total body of skills. The original identification of the components was guided by consideration of the discreteness of each skill and limiting the set of components to a manageable number. The listing of the components identified by the investigators is shown as Appendix #1. In addition, the Student Learning Sequence (SLS) number of each component is included.

Sequence of Instruction

The sequence of instruction in basic arithmetic computation skills is generally based upon the structure of arithmetic itself. This project attempts to determine a more effective sequencing, one based on apparent degree of difficulty of skills as determined by the investigators (see Appendix #2). The sequence of instruction is that suggested by the patterns of student knowledge as indicated by data yielded by testing P. K. Yonge middle school students. This sequence of instruction is called the Student Learning Sequence (SLS). An assumption of the use of the SLS is that it will aid a student to enter the program with initial success and to progress with a higher than usual probability of successful acquisition of each skill component.

Mode of Student Progress

The mode of acquisition and demonstration of mastery of each skill component by students in the classroom is individual and self-paced. The progress of a student through the system is independent of the progress of the other students in a classroom. Procedures of the system are designed to eliminate unnecessary student/teacher interaction and to cause those that do occur to focus on a specific purpose. The student is the one primarily responsible for determining when he or she has acquired sufficient skill in the use of each skill component to demonstrate mastery.

Materials for Student and Teacher Use

Learning Papers

A learning paper for skill components consists of problems that focus on the specific skill of the component and the answer for each of the problems of the learning paper. The format of the problem presentation is such that the actual computation of each student will not be on the learning paper. The answers are printed on the reverse side of the paper so as not to be visible to the student during initial problem observation. The format allows learning papers for more than one skill component to be printed on one sheet of paper. A sample learning paper is shown as Appendix #3.

Mastery Quizzes and Tests

A mastery quiz is prepared for each skill component. The format of the quizzes allows each student to accomplish all computation of the quiz. Each quiz is placed on a single sheet of paper and is a handwritten ditto copy with the problem presentations large enough to be easily read and with enough space provided for comfortable student computations.

Mastery tests are provided to be used at the discretion of the teacher. They are designed to test student learning of mathematically related groups of components. A sample quiz is shown as Appendix #4.

Student Progress Charts

A record of skill component mastery is maintained by each student on a chart. The chart is a grid that plots skill component numbers against the week that component is mastered. Thirty-six weeks are included. The structure of the chart and the recording procedures are designed so that the student is always recording and observing only positive indications of progress. Thus, the chart also serves to motivate continuous effort. Students view the recordings of mastery as an intangible reward; the average and above average students, particularly, view the chart as evidence of an opportunity to gain closure through mastering all components. The chart also contributes to teacher and student focus in that it provides a constant reminder of progress to date and the existence of this reminder may cause the teacher to increase the attention given to particular students. For the teacher, the student chart provides a constant reminder of a student's progress to date as well as each student's particular needs.

The chart is stapled to the inside of a standard manila folder provided for each student. This folder also provides storage for various papers related to use of the system. The student progress chart is shown as Appendix #5.

Teacher Class Record Form

The class record form is used by the teacher to maintain a record of all students' progress through the components. The class record form may serve as the teacher's master list of component acquisition in case students make errors in their charting on the student progress chart. The class record form may also serve as a basis for the teacher's grouping small numbers of students together temporarily for instruction. This form also identifies skills needing additional classroom attention. A sample record form is shown as Appendix #6.

Solution Keys

The solution keys are for the teacher. The collection contains copies of the student component mastery quizzes and tests with answers. In addition to the answers, the computation necessary to obtain the answer is shown. Such a presentation is intended to make clear to the teacher and possibly a student the required process necessary to obtain the correct answer. The keys may be put into booklet form for easy teacher use.

Suggested Procedures

The storage equipment available and the preference of individual teachers greatly affect the manner in which materials are organized for student use in the classroom. The primary criteria for determining how the materials are organized in the P. K. Yonge mathematics classrooms are low cost, ease of student access, and minimum maintenance by the teacher. Organization must include a means for storing learning papers, quizzes, and student folders so that they are available to students as they need them. A designated place for completed quizzes is also helpful.

Discarded ditto and mimeo paper boxes are adequate for these purposes. The learning papers and quizzes are displayed on a table in the classroom in folders kept in the "discarded" boxes. One of the boxes is assigned to receive quizzes as students finish them. The student folders are simply stacked by the class on a book shelf in the classroom.

Procedures vary as a result of student skill level or teacher preference, but, in general, a student begins or continues his progress in the system by obtaining learning paper number one, or the particular one for which he is ready as determined by the teacher, and returning to a work place. The format of the learning paper requires that the student copy each problem on a work paper in order to have room for computation. Answers are verifiable by the student by looking at the answers on the back of the learning paper. If the student does not succeed by following this, he seeks some instruction in this skill from the teacher or another student. Students are encouraged to help each other with the learning paper work as, clearly, one teacher cannot serve as an adequate resource for several students on several different topics simultaneously.

In any case, at some point the student decides that he has completed enough learning paper problems correctly to be able to demonstrate mastery of the component. It is important to emphasize that the student is given the major responsibility for determining readiness for a mastery quiz. Student recognition of his or her readiness to attempt a quiz is an important element in the self-paced mode of progress.

The student then obtains the proper component mastery quiz or test and begins to complete it. Students learn to differentiate between the characteristics of learning paper work and quiz work, recognizing that working together is encouraged on learning paper work and is not permitted during a quiz. Setting up a quiz area in the classroom or establishing a different time during the class period or week for quizzes helps emphasize these differences. Upon completing a quiz, the student places it in the location designated for completed quizzes.

The student then continues to progress in the system by beginning work on the next learning paper problems. Frequently, the end of a class period will interrupt the work of a student before he or she finishes a quiz or learning paper. Unfinished work is then stored in his or her folder until the next class period devoted to the computation skill system.

The teacher, or an aide if available, checks the student mastery quizzes using the Solution Keys. The criterion for student mastery of a skill component is that the student not miss more than one of the quiz problems. The successful completion of a mastery quiz is recorded on the teacher's class record forms and mastery is indicated on the student's quiz by a large check at the top. The teacher also records unsuccessful attempts to indicate that the student is not using the learning papers correctly and is attempting quizzes before acquiring the skill required by the component.

If the student does not satisfy the criterion and misses more than one problem for mastery of the skill component, an "X" is placed at the top of the quiz paper. The nature of the student's errors and suggestions as to how the student may eliminate such mistakes is noted on the quiz.

An important decision that the teacher makes about each student when a quiz is not completed satisfactorily is to prescribe activities which will insure ultimate mastery of the skill. The nature of the

student's difficulty determines the prescribed activities. These range from a simple correction of a small error on the quiz, with subsequent resubmission for grading, to a reworking of appropriate learning paper problems and checking their solutions with the teacher prior to a repeated attempt of the entire component quiz. Again, when possible, other students may provide assistance. In all cases, the submission of a mastery quiz is repeated by the student. This process continues until the student achieves mastery of the component.

At a convenient time the teacher returns the quizzes that have been graded. The students use their student progress form to record mastery of components as quizzes that are marked correct are returned. Mastery of the component is recorded by the student's filling in the cell of the student progress form that corresponds with the component number and the week in which the quiz is submitted. Only positive information is recorded on the student's progress chart.

The integrity of the component mastery quizzes is maintained by encouraging students not to keep correct quizzes after they have recorded them on their student progress form. The bulk of the folders is reduced, and learning papers are generally kept available by encouraging students to discard work papers and return learning papers to their storage place after recording the corresponding correct mastery quiz.

In general, the time that a classroom is devoting to this system is a time in which students are working independently. Students or small groups of students may be engaged in similar activities, but the specific nature of a student's activity is determined by his or progress through the system.

It must be emphasized that the basic computation skills system is designed to be an important part, but only a part, of the instruction of arithmetic which is, in turn, an important part, but only a part, of the instruction of middle school mathematics. Since the use of the system implies independent participation by individual students or in some cases participation by students in small groups, the relative part of the classroom instruction that the system comprises will vary from student to student. The system is available for those times when the teacher wishes to focus on computation skills with an individual, self-paced mode of instruction. Use of the system will increase the need for the teacher to provide for independent study by more able students since the system allows the more able student to demonstrate mastery of all of the skills quicker. These independent study activities should emphasize enrichment and maintenance of these skills.

CHAPTER II

A COMPARISON OF THE P. K. YONGE COMPUTATION PROGRAM AND THE STATE STUDENT ASSESSMENT TEST

The Florida Educational Accountability Act of 1976 is being implemented by the Florida Statewide Assessment Program (FSAP) through the use of the State Student Assessment Test, Parts I and II (SSAT-I, II). The SSAT-I measures the performance of students in grades 3, 5, 8, and 11 in Communication Skills and Mathematics Tests. (SSAT-II is the Functional Literacy Test.) The Mathematics Test of SSAT-I groups sixty-eight skills into twenty-three standards, which in turn are grouped into six sets, namely: Number Concepts, Computation, Fractions, Decimals, Measurement, and Practical Problems. The SSAT-I has a minimum of two test items per skill tested. For example, in grade 8, the skill "Add 3 numbers, each having fewer than 3 decimal places" is one of the skills grouped in the standard "Add and subtract decimals" which is grouped in the set designated "Decimals." This skill has five test items on the SSAT-I. The P. K. Yonge Computation System of 1978-1979 included fifty skills that roughly parallel those skills of the SSAT-I in the three groups Computation, Fractions, and Decimals.

A revision was made in the summer of 1979 to make the System compatible with the SSAT-I. The revision more closely parallels the three groups listed above as well as Number Concepts. The learning of those skills in the groups of Measurement and Practical Problems is not compatible with the P. K. Yonge System at this time.

Table 1 shows the scope of the P. K. Yonge Computation System compared to the Assessment Tests.

Table 2 compares the SSAT-I Mathematics Test to the P. K. Yonge Computation System. In using the table it is important to note: (1) the SSAT-I category of Computation includes whole numbers only; (2) the letter designation for standards is that of the SSAT-I; (3) the standard of "Divide fractions" is not covered by the SSAT-I and therefore has no letter designation; (4) an "N" indicates the number of new skills tested at any grade; (5) a "C" indicates a continuation (usually at a higher degree of difficulty or slightly different form) of testing a previously tested skill; and (6) although the P. K. Yonge System is not designed for grades K-4 and 9-12, it includes the grades 3 and 11 skills of the SSAT-I.

Care was taken in revising the P. K. Yonge System for 1979-1980 to include every skill at a similar degree of difficulty as well as at a higher degree of difficulty. For example, the highest degree of difficulty of the SSAT-I skill "Subtract whole numbers" is "Subtract any two 5-digit numbers." The P. K. Yonge Program includes this skill as well as a more difficult one dealing with subtraction of any two 6-digit numbers. In

TABLE 1

A Comparison of the P. K. Yonge Computation System
and the State Student Assessment Test

SSAT-I, II

Mathematics	Communication Skills
Grade 3 5 8 11	Grade 3 5 8 11
Part I (Basic Skills) Number Concepts Computation Fractions Decimals	← P. K. Yonge Computation System
Measurement Practical Problems	
Part II (Functional Literacy) Grade 11	Grade 11

TABLE 2

A Comparison of the Minimum Performance
Standards and Skills in Mathematics from SSAT-I
and the Standards and Skills from the P. K. Yonge System

Standards	Skills						
	Grade				Total Skills		
	3 N/C	5 N/C	8 N/C	11 N/C	SSAT	PKY 78-79	PKY 79-80
Number Concepts							
A. Count quantities	1/0	0/1	-	-	1	0	0*
B. Read and write numbers	1/0	1/1	-	-	2	0	2
C. Round numbers	-	1/0	1/0	2/0	4	0	5
D. Put numbers in order	1/0	1/1	-	1/0	3	0	0*
E. Determine equivalent form of fractions, decimals and percents	1/0	1/0	4/0	3/0	9	4	7**
Subtotal of Number Concept Skills					19	4	14
Computation							
F. Add whole numbers	2/0	1/1	1/0	-	4	4	4
G. Subtract whole numbers	3/0	0/2	0/1	-	3	6	6
H. Multiply whole numbers	-	2/0	0/1	1/0	3	4	4
I. Divide whole numbers	-	1/0	1/0	1/0	3	7	7
Subtotal of Computation Skills					13	21	21
Fractions							
J. Add and subtract fractions	-	2/0	1/0	3/0	6	9	9
K. Multiply fractions	-	-	1/0	1/0	2	3	4
Divide fractions	-	-	-	-	0	2	2
Subtotal of Fraction Skills					8	14	15
Decimals							
L. Add and subtract decimals	-	-	1/0	-	1	4	4
M. Multiply and divide decimals	-	-	3/0	2/0	5	7	7
N. Find percentages	-	-	-	2/0	2	0	2
Subtotal of Decimal Skills					8	11	13
Total of Comparative Skills					48	50	63

* This skill is included in the readiness activities of the system
** The third and fifth grade skills are included in the readiness activities of the system.

many cases, the P. K. Yonge Program includes more skills for a standard than does the SSAT-I. These skills deal with skills such as horizontal presentation of problems and significant zeroes in problems and answers. In one instance, another standard (dividing fractions) is included in the P. K. Yonge Program, although it is not in SSAT-I.

Mastery of a skill in the SSAT-I may be demonstrated even though more than one of the test items for that skill was missed. Mastery of a skill in the P. K. Yonge Program is determined by missing no more than one answer per set of test items (always five or more). Mastery of a standard in the SSAT-I may be demonstrated even though more than one of the test items for that standard is missed. Mastery of a standard in the P. K. Yonge Program is determined by correctly answering all test items for that standard on a separate test.

This comparison shows that the P. K. Yonge Computation Program subsumes the SSAT-I in content. Furthermore, the the Program exceeds the SSAT-I in rigor.

CHAPTER III

EVALUATION

The P. K. Yonge Computation Program was used in the mathematics classrooms of grades six, seven, and eight of the P. K. Yonge Laboratory School during the 1978-1979 school year. Each of the grades consisted of two classes of thirty students who were taught by a different member of the P. K. Yonge mathematics department.

The population of the sixth grade mathematics classes included all of the fifty-one sixth grade students enrolled in P. K. Yonge. The population of the seventh grade mathematics classes was diminished by ten students who were enrolled in special classes; one of the ten was enrolled in an eighth grade mathematics class, and the remaining nine students were placed in an advanced seventh grade mathematics class. The population of the eighth grade mathematics classes was diminished by thirteen students who had also been designated as superior mathematics students and were, therefore, enrolled in Algebra I classes.

The computation skill achievement of the students who used the P. K. Yonge Computation Program was measured by the mathematics computation section of the advanced Metropolitan Achievement Test (1971). The test includes forty items and was administered in September 1978 and June 1979. Pretest and posttest data were available for a total of 133 students.

Table 3, below, presents the mean raw scores obtained on the pretest and posttest by the three grades and the total student population. In order to place the mean raw scores in reference to some continuum of achievement, the corresponding grade equivalent score was determined for each mean raw score. The standard deviation for each group of raw scores was also determined. The final column of the table indicates the changes in the corresponding grade equivalent scores.

TABLE 3

Pre- and Posttest Mean Raw Scores
(Total Population and by Grade)

Subgroup	n	Pretest			Posttest			Grade Equivalent Change
		Mean Raw Score	Grade Equivalent	Standard Deviation	Mean Raw Score	Grade Equivalent	Standard Deviation	
Total Population	133	16.80	6.2	7.59	24.65	8.1	10.02	+ 1.9
Sixth Grade	51	13.55	5.4	6.74	24.22	7.9	11.58	+ 2.5
Seventh Grade	41	16.85	6.2	5.96	24.15	7.9	8.43	+ 1.7
Eighth Grade	41	20.80	7.1	8.23	25.83	8.1	9.52	+ 1.0

The data presented in Table 3 indicate that each grade level produced an increase in mean raw score equivalent to a change in grade equivalent of one year or more. The grade equivalent gain of the total group is almost two years. The sixth grade gain is striking. The standard deviation at each grade level is larger for the posttest data than for the pretest data.

In order to further examine the results of the use of the P. K. Yonge Computation Program, each grade level was divided into four subgroups to approximate quartile groups based on the pretest raw scores. Table 4 presents the information of Table 3 for each of the subgroups. The subgroup designations correspond to that quartile that each subgroup approximates.

TABLE 4

Pre- and Posttest Mean Raw Scores
(Subgroups)

Subgroup	n	Pretest			Posttest			Grade Equivalent Change
		Mean Raw Score	Grade Equivalent	Standard Deviation	Mean Raw Score	Grade Equivalent	Standard Deviation	
6-1	12	23.00	7.7	3.64	30.50	9.4	5.11	+ 1.7
6-2	14	15.07	5.7	1.59	29.79	9.1	6.22	+ 3.4
6-3	13	10.69	4.8	0.85	22.46	7.5	4.46	+ 2.7
6-4	12	5.42	3.7	2.68	13.33	5.3	5.97	+ 1.6
7-1	9	24.78	8.1	1.92	30.78	9.5	6.55	+ 1.4
7-2	12	19.33	6.7	1.23	29.08	8.8	3.87	+ 2.1
7-3	9	14.67	5.7	1.87	21.00	7.1	7.68	+ 1.4
7-4	11	9.45	4.5	2.54	15.91	6.0	5.84	+ 1.5
8-1	10	31.60	9.7	2.59	33.20	9.8	5.24	+ .1
8-2	11	24.00	7.9	1.67	30.64	9.5	4.90	+ 1.6
8-3	10	16.90	6.2	2.47	25.20	8.1	7.10	+ 1.9
8-4	10	10.40	4.7	2.41	13.80	5.4	6.96	+ .7

Each of the identified subgroup of Table 4, except 8-1 and 8-4, produced a grade equivalent gain of more than one year. Each of the sixth grade groups, and 7-2, 7-4, 8-2, and 8-3 produced a grade equivalent gain of a year and one-half or more. Again, the posttest standard deviations of each subgroup were greater than the corresponding pretest standard deviations. The small grade equivalent gain of subgroup 8-1 may be explained by noting that this subgroup began use of the computation system very near the maximum grade equivalent possible.

In order to establish a reference for a statistical evaluation of the achievement of the population of students who used the P. K. Yonge Computation Program, expected posttest raw scores were computed for each student. Each expected posttest grade equivalent score was obtained by adding .9 to the pretest grade equivalent score. The expected posttest raw scores were determined from the corresponding expected grade equivalent scores. The increase of .9 in grade equivalent score corresponds to the nine-month elapsed time between the administration of the pretest and posttest. The actual posttest raw scores were then compared with the expected posttest raw scores. Table 5 presents this comparison.

TABLE 5

Comparison of Actual and Expected Posttest Scores

Subgroup	n	Mean Raw Scores		Pearson Product Correlation Coefficient	t-Value
		Actual Post	Expected Post		
Total Population	133	24.69	20.92	.610	5.28*
Sixth Grade	51	24.22	17.47	.535	4.90*
Seventh Grade	41	24.15	20.71	.754	3.97*
Eighth Grade	41	25.83	25.44	.727	0.36*

* Significant at the 0.05 level

Table 5 shows that for each subgroup identified the posttest mean raw score exceeded the expected posttest mean raw score. The differences by which the posttest mean raw scores exceeded the corresponding expected posttest mean raw score were statistically significant for the total population and the sixth and seventh grades.

Additional information concerning the nature of the entering computational skill level of the population of the subgroups can be obtained by examining the range of the pretest grade equivalent scores for each of the subgroups. Table 6 presents this information. It is important to note that the maximum grade equivalent possible for the test is 9.9.

Table 6 indicates that each grade level has an inordinate range of grade equivalent scores.

TABLE 6

Range of Pretest Grade Equivalent Scores

Groups	n	Low Pretest Grade Equivalent	High Pretest Grade Equivalent	Range of Grade Equivalent
Total Population	133	1.9	9.8	7.9
Sixth Grade	51	1.9	9.6	7.7
Seventh Grade	41	2.9	8.8	5.9
Eighth Grade	41	3.9	9.8	5.9
Subgroups				
6-1	12	6.7	9.6	3.2
6-2	14	5.3	6.5	1.2
6-3	13	4.6	5.0	0.4
6-4	12	1.9	4.3	2.4
7-1	9	7.7	8.8	1.1
7-2	12	6.5	7.1	0.6
7-3	9	5.3	6.2	1.9
7-4	11	2.9	5.0	2.1
8-1	10	8.5	9.8	1.3
8-2	11	7.1	8.1	1.0
8-3	10	5.5	6.9	1.4
8-4	10	3.9	5.3	1.4

Table 7 presents the number of students in each grade who were above, at, or below grade level as measured by the pretest and as later measured by the posttest. It indicates that approximately two-thirds of the students in each grade began the year below grade level and only one-third of the students ended the year below grade level.

TABLE 7

Student Changes In Grade Level

Subgroup	n	Pretest				Posttest			
		Below Grade Level		At or Above Grade Level		Below Grade Level		At or Above Grade Level	
		n	%	n	%	n	%	n	%
Total Population	133	90	67.7	43	32.3	51	38.3	82	61.7
Sixth Grade	51	34	$66.\overline{6}$	17	$33.\overline{3}$	16	31.4	35	68.6
Seventh Grade	41	29	70.7	12	29.3	18	43.9	23	56.1
Eighth Grade	41	27	65.9	14	34.1	17	41.5	24	58.5

In order to consider the existence of a pattern of change of the status of the test grade level in relation to the actual grade level, the number of students who retained or changed their relative grade-level status was determined. Table 8 presents the number of students in each grade level and their change in grade-level status during the year.

TABLE 8

Changes in Student Grade Level Status

Subgroup	n	At or Above Grade Level on Pretest to At or Above Grade Level on Posttest	At or Above Grade Level on Pretest to Below Grade Level on Posttest	Below Grade Level on Pretest to At or Above Grade Level on Posttest	Below Grade Level on Pretest to Below Grace Level on Posttest
Total Population	133	37	6	45	45
Sixth Grade	51	16	1	19	15
Seventh Grade	41	9	3	14	15
Eighth Grade	41	12	2	12	15

Each student is listed in one and only one of the four possible changes in status listed. The data indicate that the great majority of students who began at or above grade level remained there. The data also indicate that roughly one-third of all the students of each of the grades began below grade level and changed to at or above grade level during the year. Roughly one-third of the students at each grade began below grade level and remained there.

CHAPTER IV

DISCUSSION OF THE RESULTS

As part of the general evaluation of the use of the P. K. Yonge Computation System, it is important to note that the program was used in the classroom of three different teachers. Hence, the generally positive results of the use of the system cannot be attributed to the teacher variable. The positive results cannot be attributed to special characteristics of the student population either, as the pretest data indicate a heterogeneous student group with a wide range of grade equivalent scores.

In general, the students who used this program obtained positive changes in grade equivalent scores of more than one year. Several of the student subgroups obtained positive changes in grade equivalent scores of more than one year as evidenced by the change in mean raw score of the total student population from pretest to posttest. This positive change in grade equivalent was equal to 1.9 years. There was also an over-all increase in the standard deviations of the subgroups, indicating that application of the system allows the individual student to become more independent of the group to which he is assigned as he or she increases computation skills.

Of particular interest is the indication that for each grade the students in the second and third quartiles showed the greatest gains in grade equivalent scores. This is a further indication that the program allows a student through acquisition of computation skills to become more independent of the total group. The low gain of the first quartile of the eighth-grade students is attributed to their entering the program with a skill level very close to the maximum measured by the evaluative instrument. The low gain of the fourth quartile at the eighth grade level is noteworthy. The investigators believe that it points up, again, a fact that is well known to middle school mathematics teachers--that it is critically important to correct computation deficiencies as early as possible. If students have not mastered basic computation skills by the time they reach the eighth grade, many have psychological blocks which seriously interfere with their mastery. Additional attention by the investigators will be directed toward solution of this problem. However, it is likely that no solution will be found which is as satisfactory as rigorous application of procedures described in this monograph before students reach the eighth grade.

It is also important when considering the general results of the use of the system to examine the nature of the goal of any computation skill system. An absolute goal would be that all participating students end the school year at or above grade level in computation skills. This goal was met for most, but not all, students, as roughly one-third of the student population ended the school year below grade level in computation skills. However, the P. K. Yonge system did result in significant growth in terms of this goal, as roughly two-thirds of the students

began the program below grade level in computation skills. A relative goal would be that all participating students show individual gain in grade equivalent scores of at least one year. This goal was met by the majority of students; further, an indication that this goal was clearly met for the total population in general is the mean raw score gain of the total population equivalent to a positive grade equivalent change of 1.9 years.

The investigators conclude that data yielded by this study indicate that the P. K. Yonge Computation System produces results that are clearly positive. Further, the results are sufficiently positive to warrant examination of the use of the system in public school classrooms.

The system will continue being used, evaluated, and revised at P. K. Yonge as well as at other schools wishing to use it. Results, so far, indicate that use of the system, as is, will benefit the second and third quartiles most. Closer examination of the fourth quartile is needed, particularly in the eighth grade. The results of the sixth grade suggest the possibility of its use in the fifth grade.

Three important questions remain to be investigated. The first deals with the effect of the use of the SLS as opposed to a more traditional sequencing of instruction. The second deals with the possible loss of skill during the summer months. The third deals with the use of time with the system in classrooms. Additional activities may be needed for those students completing the system more quickly than others; total amount of time used in a year and frequency of use need to be studied. These questions will be addressed through experimental and longitudinal studies as well as through conferences with interested educators.

APPENDIXES

APPENDIX #1

Arithmetic Skill Components

	SLS Number
I. Whole Numbers	
A. General Skills	
1. Given a numeral for a whole number, write its name.	1
2. Given a whole number name, write its numeral.	2
3. Round a whole number name to the nearest ten.	3
4. Round a whole number to the nearest hundred.	4
B. Addition	
1. Add two wholes, no regrouping	5
2. Add two wholes, with regrouping	7
3. Add columns of several wholes	14
4. Add several wholes, horizontal presentation	38
C. Subtraction	
1. Subtract wholes, no regrouping, vertical presentation	6
2. Subtract wholes, no regrouping, horizontal presentation	28
3. Subtract wholes, one regrouping	12
4. Subtract wholes, more than one regrouping	19
5. Subtract wholes, regroup through one zero	15
6. Subtract wholes, regroup through more than one zero	22
D. Multiplication	
1. Multiply whole by one digit whole	8
2. Multiply whole by two digit whole	20
3. Multiply whole by three digit whole	49
4. Multiply whole by whole with zero(s) in the factor(s)	36
E. Division	
1. Divide whole by one digit factor with two digit quotient	16
2. Divide whole by one digit whole with a one digit mixed number quotient	23
3. Divide whole by a one digit whole with a more than one digit mixed number quotient	25
4. Divide whole by a one digit whole with a significant zero in the quotient	37
5. Divide whole by a two digit whole with a mixed number quotient	42
6. Divide whole by three digit whole with a mixed number quotient	51
7. Divide whole by three digit whole with more than one significant zero juxtaposed in the quotient	46

	SLS Number
II. Fractions	
A. General Skills	
1. Change improper fraction to mixed number	34
2. Simplify fractions by reducing to lowest terms	32
3. Change fraction to equivalent fraction with denominator a multiple of the original denominator	35
4. Change a mixed number to an improper fraction	41
5. Round a mixed number to the nearest whole	31
B. Addition	
1. Add fractions with like denominators	13
2. Add fractions with like denominators, simplify answer	29
3. Add whole and mixed number	17
4. Add two mixed numbers with like denominators	18
5. Add three mixed numbers with like denominators, simplify answer	48
6. Add more than two fractions or mixed numbers with unequal denominators	56
C. Subtraction	
1. Subtract fractions or mixed numbers with same denominators, no regrouping	24
2. Add or subtract two fractions or mixed numbers with unequal denominators, one denominator a factor of the other	44
3. Add or subtract two fractions or mixed numbers with unequal denominators	39
4. Subtract mixed numbers with regrouping necessary	57
D. Multiplication	
1. Multiply two fractions	27
2. Find a fractional part of a whole number that is a multiple of the denominator	54
3. Multiply two mixed numbers	58
E. Division	
1. Divide a fraction or mixed number by a fraction or mixed number	47
2. Divide a whole by a unit fraction	53
III. Decimals/Per Cent	
A. General Skills	
1. Round a decimal to the nearest tenth	9
2. Round a decimal to the nearest whole number	10
3. Change decimal to the whole number per cent	59
4. Change per cent to proper fraction	60
5. Change per cent to improper fraction	61
B. Addition	
1. Add decimals, vertical presentation	11
2. Add decimals, horizontal presentation	26

	SLS Number
C. Subtraction	
1. Subtract decimals, vertical presentation	21
2. Subtract decimals, horizontal presentation, zero must be added to minuend	50
D. Multiplication	
1. Multiply by two decimals	40
2. Multiply two decimals, significant zero required in product	43
3. Find whole number per cent of a whole number	62
4. Find a decimal or mixed number per cent of a decimal number	63
E. Division	
1. Divide decimal by whole, quotient terminates, no zero required in dividend	30
2. Divide decimal fraction by whole, quotient terminates one or more zeros needed in dividend	45
3. Divide decimal by decimal fraction, answer terminates	33
4. Divide decimal by decimal with repeating quotient	52
5. Divide whole by larger whole, decimal quotient required	55

APPENDIX #2

Student Learning Sequence

1. Given a numeral for a whole number, write its name.
2. Given a name for a whole number, write its numeral.
3. Round a whole number to the nearest ten.
4. Round a whole number to the nearest hundred.
5. Add two whole numbers without regrouping.
6. Subtract whole numbers without regrouping vertical presentation.
7. Add two whole numbers with regrouping.
8. Multiply a whole number by a one digit whole number.
9. Round a decimal to the nearest tenth.
10. Round a decimal to the nearest whole number.
11. Add decimal numbers, vertical presentation.
12. Subtract whole numbers, one regrouping.
13. Add fractions, like denominators.
14. Add several whole numbers, vertical presentation.
15. Subtract whole numbers.
16. Divide whole numbers by a one digit whole number with a two digit whole number quotient.
17. Add a whole number and a mixed number.
18. Add two mixed numbers with like denominators.
19. Subtract whole numbers, more than one regrouping.
20. Multiply a whole number by a two digit whole number.
21. Subtract whole numbers, vertical presentation.
22. Subtract whole numbers, regroup through more than one zero.
23. Divide a whole number by a one digit whole number with a one digit mixed number quotient.
24. Subtract fractions or mixed numbers with like denominators, no regrouping.
25. Divide a whole number by a one digit whole number with a more than one digit mixed number quotient.
26. Add decimal numbers, horizontal presentation.
27. Multiply two fractions.
28. Subtract whole numbers, no regrouping, horizontal presentation.
29. Add fractions with like denominators, simplify answer.
30. Divide a decimal number by a whole number, quotient terminates.

31. Round a mixed number to the nearest whole.
32. Simplify fractions by reducing to lowest terms.
33. Divide decimal numbers, quotient terminates.
34. Change improper fraction to mixed number.
35. Change a fraction to an equivalent fraction, denominator a multiple of original denominator.
36. Multiply whole numbers with zeroes in the factors.
37. Divide a whole number by a one digit whole number with a significant zero in the quotient.
38. Add several whole numbers, horizontal presentation.
39. Add or subtract two denominators with unlike denominators.
40. Multiply two decimal numbers.
41. Change a mixed number to an improper fraction.
42. Divide a whole number by a two digit whole number with a mixed number quotient.
43. Multiply two decimals, significant zero in product.
44. Add or subtract two fractions or mixed numbers, one denominator a factor of the other.
45. Divide a decimal number by a whole number, quotient terminates, one or more significant zeroes in dividend.
46. Divide a whole number by a three digit whole number with more than one zero juxtaposed in quotient.
47. Divide fractions or mixed numbers.
48. Add three mixed numbers with like denominators, simplify answer.
49. Multiply three digit whole numbers.
50. Subtract decimal numbers, horizontal presentation, add zero to minuend.
51. Divide a whole number by a three digit whole number, with a mixed number quotient.
52. Divide decimal numbers, quotient has a repetend.
53. Divide a whole number by a unit fraction.
54. Find a fractional part of a whole number that is a multiple of the denominator.
55. Divide a whole number by a larger whole number, decimal quotient required.
56. Add two or more fractions or mixed numbers with unlike denominators.
57. Subtract mixed numbers with regrouping.

58. Multiply two mixed numbers.
59. Change a decimal number to a whole number per cent.
60. Change a per cent to a proper fraction.
61. Change a per cent to an improper fraction.
62. Find a whole number per cent of a whole number.
63. Find a decimal or mixed number per cent of a decimal number.

APPENDIX #3

Sample Learning Papers

---Set 39---

A. $\frac{1}{2} + \frac{3}{4}$ B. $\frac{1}{2}$ C. $\frac{3}{4} + \frac{5}{8}$ D. $1\frac{1}{2} + \frac{3}{4}$ E. $2\frac{2}{3} + 3\frac{3}{4}$

F. $\frac{3}{5}$ $+\ \frac{2}{3}$ $\frac{+\ \frac{1}{4}}{}$ G. $2\frac{3}{4}$ $+\ 1\frac{5}{8}$ H. $2\frac{2}{3} + 5\frac{1}{7}$ I. $6\frac{2}{5}$ $+\ 3\frac{1}{4}$ J. $9\frac{2}{3} + 5\frac{2}{9}$

K. $6\frac{3}{5} + 2\frac{1}{2}$ L. $8\frac{5}{6} + 2\frac{2}{3}$ M. $3\frac{5}{12} + 8\frac{2}{3}$ N. $2\frac{3}{8} + 1\frac{2}{3}$

O. $9\frac{5}{6} + 3\frac{4}{10}$ P. $2\frac{3}{5} + 4\frac{5}{12}$ * $6\frac{9}{23} + 5\frac{4}{11}$

---Set 40---

A. 3.1 x 5 B. 7 x .8 C. 2.1 x 1.4 D. 8.4 x .03 E. 2.13 x 5.6

F. 8.24 x 3.21 G. .083 x 1.56 H. 42.1 x .035 I. 9.264 x 23

J. 82.61 x 7.365 K. 90.60 x 5.03 * 4.216 x .000351

---Set 41 Change to an improper fraction---

A. $1\frac{1}{2}$ B. $2\frac{2}{3}$ C. $1\frac{3}{4}$ D. $5\frac{5}{6}$ E. $4\frac{5}{12}$ F. $3\frac{3}{8}$ G. $9\frac{1}{16}$

H. $4\frac{3}{7}$ I. $9\frac{5}{11}$ J. $6\frac{7}{13}$

* $21\frac{19}{23}$

---Set 42---

A. 432 ÷ 10 B. 603 ÷ 13 C. 786 ÷ 17 D. 984 ÷ 35 E. 963 ÷ 72

F. 4316 ÷ 318 G. 6021 ÷ 215 H. 9034 ÷ 878 I. 2864 ÷ 305

J. 62174 ÷ 3162 * 90876251 ÷ 9235

Answer Set 39

A. $1\frac{1}{4}$ B. $\frac{3}{4}$ C. $1\frac{3}{8}$ D. $2\frac{1}{4}$ E. $6\frac{5}{12}$ F. $1\frac{4}{15}$ G. $4\frac{3}{8}$

H. $7\frac{17}{21}$ I. $9\frac{13}{20}$ J. $14\frac{8}{9}$ K. $9\frac{1}{10}$ L. $11\frac{1}{2}$ M. $12\frac{1}{12}$

N. $4\frac{1}{24}$ O. $13\frac{7}{30}$ P. $7\frac{1}{60}$ * $11\frac{191}{253}$

Answer Set 40

A. 15.5 B. 5.6 C. 2.94 D. .252 E. 11.928 F. 26.4504

G. 0.12948 H. 1.4735 I. 213.072 J. 608.42265 K. 455.718

* .001479816

Answer Set 41

A. $\frac{3}{2}$ B. $\frac{8}{3}$ C. $\frac{7}{4}$ D. $\frac{35}{6}$ E. $\frac{53}{12}$ F. $\frac{27}{8}$ G. $\frac{145}{16}$

H. $\frac{31}{7}$ I. $\frac{104}{11}$ J. $\frac{85}{13}$ * $\frac{502}{23}$

Answer Set 42

A. $43\frac{1}{5}$ B. $46\frac{5}{13}$ C. $46\frac{4}{17}$ D. $28\frac{4}{35}$ E. $13\frac{27}{72}$ F. $13\frac{182}{318}$

G. $28\frac{1}{215}$ H. $10\frac{254}{878}$ I. $9\frac{119}{305}$ J. $19\frac{2096}{3162}$

* $9840\frac{3851}{9235}$

APPENDIX # 4

Sample Quiz

18. NAME _____

A. $3\frac{2}{5} + 4\frac{1}{5}$

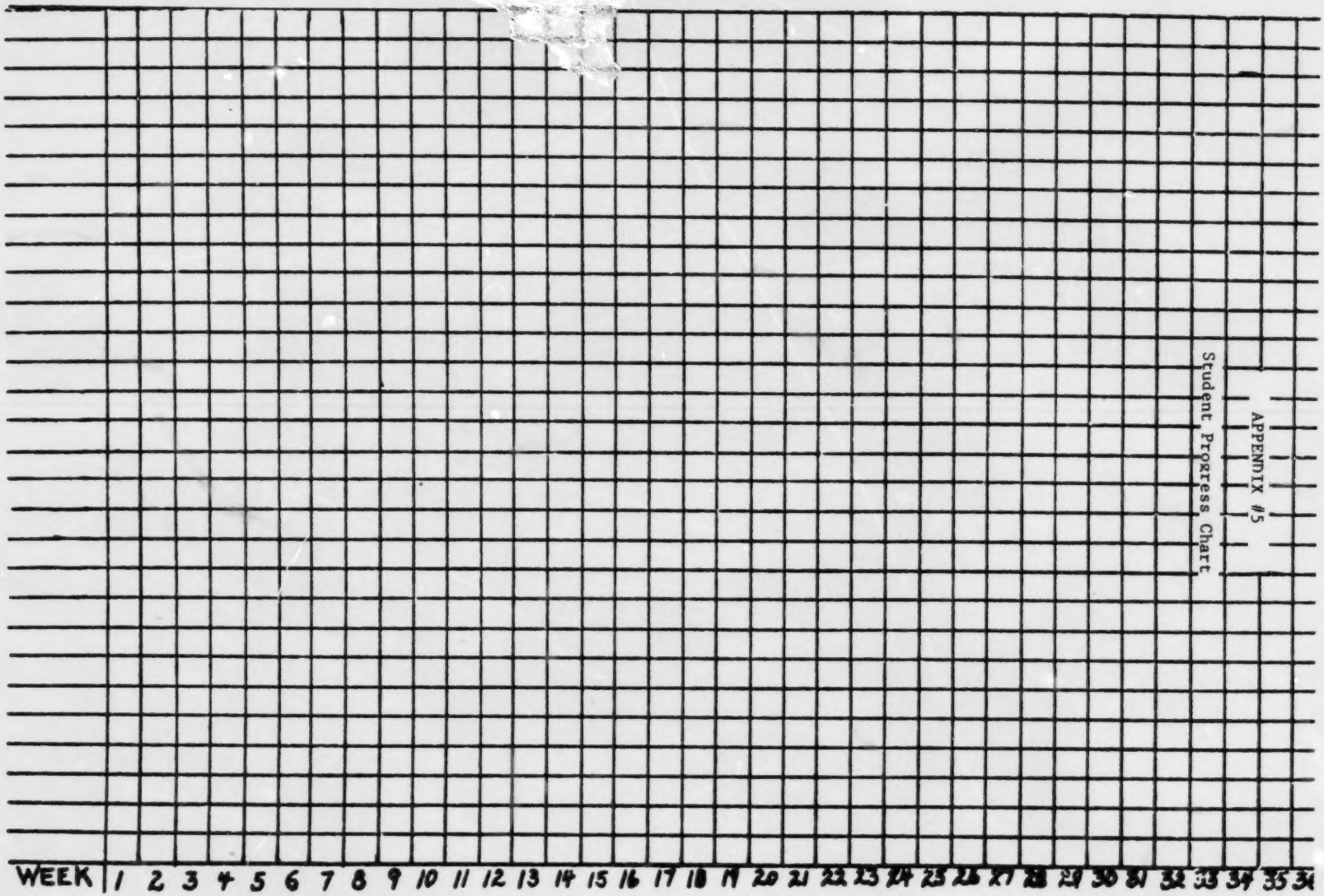
B. $3\frac{3}{7}$
$+5\frac{2}{7}$

C. $6\frac{4}{9} + 2\frac{1}{9}$

D. $14\frac{3}{8}$
$+5\frac{2}{8}$

E. $21\frac{3}{4}$
$+42\frac{3}{4}$

F. $34\frac{15}{35} + 21\frac{16}{35}$



APPENDIX #5

Student Progress Chart

APPENDIX #6

SECTION _____ CLASS RECORD _____ SIX WEEKS

NAME	WEEK 1	2	3	4	5	6